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TAPERCUT.DWPI,TDBD,EPAB,JPAB,USPT,PGPB.	8
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MR 324/318 Tapered coil

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☐ 1. Document ID: US 6344745 B1 Relevance Rank: 46

L3: Entry 6 of 9 File: USPT Feb 5, 2002

US-PAT-NO: 6344745
DOCUMENT-IDENTIFIER: US 6344745 B1
**** See image for Certificate of Correction ****

TITLE: Tapered birdcage resonator for improved homogeneity in MRI

DATE-ISSUED: February 5, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Reisker; Theodore J.	Wexford	PA		
Monski; William J.	Sewickley	PA		
Reid; Eric D.	Farmington	PA		
Misic; George J.	Allison Park	PA		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Medrad, Inc.	Indianola	PA			02

APPL-NO: 09/ 449256 [PALM]
DATE FILED: November 24, 1999

PARENT-CASE:
CROSS-REFERENCE TO RELATED APPLICATIONS This application claims the benefit of U.S. provisional application No. 60/109,831 filed Nov. 25 1998.

INT-CL: [07] G01 V 3/00

US-CL-ISSUED: 324/318; 600/421
US-CL-CURRENT: 324/318; 600/421

FIELD-OF-SEARCH: 324/318, 324/322, 324/300, 324/306, 324/307, 324/309, 324/314, 600/421, 600/422

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
4634980	January 1987	Misic et al.	
4684895	August 1987	Misic	
4692705	September 1987	Hayes	
4731584	March 1988	Misic et al.	
4740751	April 1988	Misic et al.	
4764726	August 1988	Misic et al.	
4793356	December 1988	Misic et al.	
4797617	January 1989	Misic et al.	
4825162	April 1989	Roemer et al.	
4839594	June 1989	Misic et al.	
4841248	June 1989	Mehdizadeh	
4879516	November 1989	Mehdizadeh et al.	
4881034	November 1989	Kaufman et al.	
4920318	April 1990	Misic et al.	
4975644	December 1990	Fox	
5136244	August 1992	Jones et al.	
5196796	March 1993	Misic et al.	
5209233	May 1993	Holland et al.	
5256971	October 1993	Boskamp	
5258717	November 1993	Misic et al.	
5315251	May 1994	Derby	
5348010	September 1994	Schnall et al.	
5355087	October 1994	Claiborne et al.	
5517120	May 1996	Misic et al.	
5521506	May 1996	Misic et al.	
5602479	February 1997	Srinivasan et al.	
5610520	March 1997	Misic et al.	
5998999	December 1999	Richard et al.	
6040697	March 2000	Misic	
6051974	April 2000	Reisker et al.	
6060883	May 2000	Knuttel	324/318
6100691	August 2000	Yeung	324/318
6177797	January 2001	Srinivasan	
6223065	April 2001	Misic et al.	

OTHER PUBLICATIONS

Lin et al., (1998), Magnetic Resonance in Medicine, "A Novel Multi-segment Surface Coil for Neuro-Functional Magnetic Resonance Imaging," vol. 39, pp. 164-168.
Meyer et al, (1995), Journal of Magnetic Resonance, Series B, "A 3.times.3 Mesh Two-Dimensional Ladder Network Resonator of MRI of the Human Head,"vol. 107, pp. 19-24.

Roemer, et al., (1990), Magnetic Resonance in Medicine, "The NMR Phased Array," vol. 16, pp. 192-225.

ART-UNIT: 2862

PRIMARY-EXAMINER: Arana; Louis

ATTY-AGENT-FIRM: Sampson; Matthew J. Bradley; Gregory L.

ABSTRACT:

A method for creating improved homogeneity in magnetic flux density in a radio frequency resonator for magnetic resonance imaging and spectroscopy of the human head. A tapered birdcage resonator is also provided. The tapered birdcage resonator includes two electrically conductive rings and a plurality of rods or conductor legs. The first

electrically conductive ring forms an inferior end of the coil. The plurality of legs extends from the first electrically conductive ring. Each of the plurality of legs has a linear portion and a tapered portion. The second electrically conductive ring forms a superior end of the coil and is connected to the tapered portion of the plurality of legs.

21 Claims, 14 Drawing figures

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. Desc | Image

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☐ 2. Document ID: US 6356081 B1 Relevance Rank: 41

L3: Entry 5 of 9 File: USPT Mar 12, 2002

US-PAT-NO: 6356081
DOCUMENT-IDENTIFIER: US 6356081 B1

TITLE: Multimode operation of quadrature phased array MR coil systems

DATE-ISSUED: March 12, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Misic; George J.	Allison Park	PA		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Medrad, Inc.	Indianola	PA			02

APPL-NO: 09/ 449255 [PALM]
DATE FILED: November 24, 1999

PARENT-CASE:
CROSS-REFERENCE TO RELATED APPLICATION This application claims the benefit of U.S. Provisional Application No. 60/109,820, filed Nov. 25, 1998.

INT-CL: [07] G01 V 3/00

US-CL-ISSUED: 324/318; 600/422
US-CL-CURRENT: 324/318; 600/422

FIELD-OF-SEARCH: 324/318, 324/322, 324/300, 324/306, 324/307, 324/309, 324/314, 600/421, 600/422

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
4634980	January 1987	Misic et al.	
4684895	August 1987	Misic	
4692705	September 1987	Hayes	
4731584	March 1988	Misic et al.	
4740751	April 1988	Misic et al.	
4764726	August 1988	Misic et al.	
4793356	December 1988	Misic et al.	
4797617	January 1989	Misic et al.	
4825162	April 1989	Roemer et al.	
4839594	June 1989	Misic et al.	
4841248	June 1989	Mehdizadeh	
4879516	November 1989	Mehdizadeh et al.	
4881034	November 1989	Kaufman et al.	324/318
4920318	April 1990	Misic et al.	
4975644	December 1990	Fox	324/318
5136244	August 1992	Jones et al.	
5196796	March 1993	Misic et al.	
5209233	May 1993	Holland et al.	
5256971	October 1993	Boskamp	
5258717	November 1993	Misic et al.	
5315251	May 1994	Derby	
5348010	September 1994	Schnall et al.	
5355087	October 1994	Claiborne et al.	
5517120	May 1996	Misic et al.	
5521506	May 1996	Misic et al.	
5602479	February 1997	Srinivasan et al.	
5610520	March 1997	Misic	
5998999	December 1999	Richard et al.	
6040697	March 2000	Misic	
6051974	April 2000	Reisker et al.	
6100691	August 2000	Yeung	
6177797	January 2001	Srinivasan	324/318
6177979	January 2001	Srinivasan	
6223065	April 2001	Misic et al.	

OTHER PUBLICATIONS

Lin et al., (1998), Magnetic Resonance in Medicine, "A Novel Multi-segment Surface Coil for Neuro-Functional Magnetic Resonance Imaging," vol. 39, pp. 164-168.
Meyer et al, (1995), Journal of Magnetic Resonance, Series B, "A 3X3 Mesh Two-Dimensional Lader Network Resonator of MRI of the Human Head," vol. 107, pp. 19-24.

Roemer, et al., (1990), Magnetic Resonance in Medicine, "The NMR Phase Array," vol. 16, pp, 192-225.

ART-UNIT: 2862

PRIMARY-EXAMINER: Arana; Louis

ATTY-AGENT-FIRM: Sampson; Matthew J. Bradley; Gregory L.

ABSTRACT:

A coil interface for coupling a phased array magnetic resonance imaging coil to a magnetic resonance imaging system. The coil interface includes a plurality of signal inputs and a plurality of output ports. Each of the output ports is associated with a receiver in the magnetic resonance imaging system. The coil interface also includes an

interface circuit. The interface circuit selectively couples at least two of the signal inputs to at least one of the plurality of input ports. Where the coil is a quadrature phased array coil, a preferred embodiment allows the two quadrature signals to be acquired as a single signal, precombined at the RF level within the coil interface, or as two separate RF signals by two of the receivers of the magnetic resonance imaging system hardware.

19 Claims, 6 Drawing figures

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
Draw Desc | Image

☐ 3. Document ID: US 20020190716 A1 Relevance Rank: 39

L3: Entry 3 of 9 File: PGPB Dec 19, 2002

PGPUB-DOCUMENT-NUMBER: 20020190716
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020190716 A1

TITLE: Multimode operation of quadrature phased array MR coil systems

PUBLICATION-DATE: December 19, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Misic, George J.	Allison Park	PA	US	

US-CL-CURRENT: 324/318; 324/309, 324/322, 335/297

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
Draw Desc | Image

☐ 4. Document ID: US 20030001573 A1 Relevance Rank: 39

L3: Entry 2 of 9 File: PGPB Jan 2, 2003

PGPUB-DOCUMENT-NUMBER: 20030001573
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030001573 A1

TITLE: Multimode operation of quadrature phased array MR coil systems

PUBLICATION-DATE: January 2, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Misic, George J.	Allison Park	PA	US	

US-CL-CURRENT: 324/318; 324/309, 324/322

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
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☐ 5. Document ID: US 20030020476 A1 Relevance Rank: 38

L3: Entry 1 of 9 File: PGPB Jan 30, 2003

PGPUB-DOCUMENT-NUMBER: 20030020476
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030020476 A1

TITLE: Method and apparatus for magnetic resonance imaging

PUBLICATION-DATE: January 30, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Duensing, G. Randy	Gainesville	FL	US	

US-CL-CURRENT: 324/318; 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
Draw Desc | Image

☐ 6. Document ID: US 6404201 B1 Relevance Rank: 27

L3: Entry 4 of 9 File: USPT Jun 11, 2002

US-PAT-NO: 6404201
DOCUMENT-IDENTIFIER: US 6404201 B1

TITLE: Magnetic resonance imaging RF coil

DATE-ISSUED: June 11, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Boskamp; Eddy B.	Menomonee Falls	WI		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
GE Medical Systems Global Technology Company, LLC	Waukesha	WI			02

APPL-NO: 09/ 681972 [PALM]
DATE FILED: July 2, 2001

INT-CL: [07] G01 V 3/00

US-CL-ISSUED: 324/318; 324/319, 324/322
US-CL-CURRENT: 324/318; 324/319, 324/322

FIELD-OF-SEARCH: 324/318, 324/319, 324/322, 324/300, 324/312, 324/314, 600/422

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
5646530	July 1997	Strenk et al.	
5744957	April 1998	Vaughan, Jr.	
5886596	March 1999	Vaughan, Jr.	
6040697	March 2000	Misic	
6236206	June 2001	Harthman et al.	324/318

ART-UNIT: 2862

PRIMARY-EXAMINER: Williams; Hezron

ASSISTANT-EXAMINER: Shrivastav; Brij B.

ATTY-AGENT-FIRM: Della Penna; Michael A.

ABSTRACT:

A radio frequency (RF) coil system for resonance imaging/analysis comprising a primary coil element having a plurality of axial conductors spaced to form a generally tubular structure having two ends and defining a coil volume, and a first pair of spoiler coils. The first pair of spoiler coils each comprising a plurality of axial conductors spaced to form a generally tubular structure and defining a coil volume. Each of the spoiler coils is positioned adjacent to and overlapping an end of the primary coil. Each of the primary and spoiler coils is also adapted to carry an RF signal, wherein the signal in the spoiler coils is 180 degrees out of phase with the signal in the primary coil. The counter-phased spoiler coils act to rapidly drive down the RF magnetic field generated by the primary coil in the region of the ends of the primary coil to reduce the occurrence of aliasing artifacts from outside the imaging field of view.

20 Claims, 7 Drawing figures

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
Draw. Desc | Image

☐ 7. Document ID: US 5594342 A Relevance Rank: 25

L3: Entry 8 of 9 File: USPT Jan 14, 1997

US-PAT-NO: 5594342
DOCUMENT-IDENTIFIER: US 5594342 A

TITLE: Nuclear magnetic resonance probe coil with enhanced current-carrying capability

DATE-ISSUED: January 14, 1997

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Brey; William W.	Sunnyvale	CA		
Withers; Richard S.	Sunnyvale	CA		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Conductus, Inc.	Sunnyvale	CA			02

APPL-NO: 08/ 462663 [PALM]
DATE FILED: June 5, 1995

PARENT-CASE:
CROSS-REFERENCE TO RELATED APPLICATIONS This application is a continuation-in-part of U.S. patent application Ser. No. 08/409,506 by Richard S. Withers filed Mar. 23, 1995, and a continuation-in-part of U.S. patent application Ser. No. 08/313,624 by Richard S. Withers, Guo-Chun Liang and Marie Johansson filed Sep. 27, 1994 now abandoned, which is a continuation-in-part of Ser. No. 891,591, now U.S. Pat. No. 5,351,007 by Richard S. Withers and Guo-Chun Liang filed Jun. 1, 1992, each of which is incorporated herein by reference.

INT-CL: [06] G01 V 3/00

US-CL-ISSUED: 324/322; 324/318
US-CL-CURRENT: 324/322; 324/318

FIELD-OF-SEARCH: 324/318, 324/321, 324/322, 29/829, 29/846, 29/847, 505/192, 505/202, 505/220, 505/329, 505/844

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
2657310	October 1953	Runft	250/33
3764938	October 1973	Barnes	331/96
4346537	August 1982	Masujima et al.	51/413
4409608	October 1983	Yoder	357/51
4636730	January 1987	Bottomly	324/318
4769883	September 1988	Misic et al.	128/653.5
4792790	December 1988	Reeb	29/846
4872068	October 1989	Huang et al.	361/321
4894316	January 1990	Hjulstrom	430/316
4894629	January 1990	Okamura et al.	333/177
4981838	January 1991	Whitehead	505/1
5061686	October 1991	Ruby	565/1
5075281	December 1991	Testardi	505/1
5172461	December 1992	Pichl	29/25.42
5219827	June 1993	Higaki et al.	505/1
5231078	July 1993	Riebman et al.	505/192
5247256	September 1993	Marek	324/321
5258710	November 1993	Black et al.	324/309
5276398	January 1994	Withers et al.	324/318
5351007	September 1994	Withers et al.	324/322

FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	US-CL
WO94/05022	March 1994	WO	

OTHER PUBLICATIONS

Gupta, et al., Computer-Aided Design of Microwave Circuits, ARTECH House, Inc. 217-220 (1981).
Banson, et al., "A probe for specimen magnetic resonance microscopy" (Feb. 1992). Investigative Radiology27:157-164.
Black, et al., "A high-temperature superconducting receiver for nuclear magnetic resonance microscopy" (Feb. 5 1993) Science259:793-795.

ART-UNIT: 225

PRIMARY-EXAMINER: Arana; Louis M.

ATTY-AGENT-FIRM: DeFranco; Judith A.

ABSTRACT:

The conductive material in an RF coil disposed in the polarizing field of an NMR apparatus in miminized and the current density at each point in the coil kept constant by providing an inductive element and a set of tapered, interidigtated capacitors having a uniform gap therebetween. The invention maximizes the current-carrying capacity of the coil.

18 Claims, 22 Drawing figures

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
Draw Desc | Image

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8. Document ID: US 5565778 A Relevance Rank: 24

L3: Entry 9 of 9 File: USPT Oct 15, 1996

US-PAT-NO: 5565778
DOCUMENT-IDENTIFIER: US 5565778 A

TITLE: Nuclear magnetic resonance probe coil

DATE-ISSUED: October 15, 1996

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Brey; William W.	Sunnyvale	CA		
Anderson; Weston A.	Palo Alto	CA		
Wong; Wai H.	Monterey Park	CA		
Fuks; Luiz F.	Fremont	CA		
Kotsubo; Vincent Y.	Sunnyvale	CA		
Withers; Richard S.	Sunnyvale	CA		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Conductus, Inc.	Sunnyvale	CA			02

APPL-NO: 08/ 461559 [PALM]
DATE FILED: June 5, 1995

PARENT-CASE:
CROSS-REFERENCE TO RELATED APPLICATIONS This application is a continuation-in-part of U.S. patent application Ser. No. 08/409,506, by Richard S. Withers filed Mar. 23, 1995, and a continuation-in-part of U.S. patent application Ser. No. 08/313,624, by Richard S. Withers, Guo-Chun Liang and Marie Johansson filed Sep. 27, 1994, now abandoned which is a continuation-in-part of Ser. No. 891,549, now U.S. Pat. No. 5,351,007, by Richard S. Withers and Guo-Chun Liang filed Jun. 1, 1992, each of which is incorporated herein by reference.

INT-CL: [06] G01 V 3/00

US-CL-ISSUED: 324/318; 324/322
US-CL-CURRENT: 324/318; 324/322

FIELD-OF-SEARCH: 324/318, 324/321, 324/322, 29/829, 29/846, 29/847, 505/192, 505/202, 505/220, 505/329, 505/844

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
4694283	September 1987	Reeb	29/846
5247256	September 1993	Marek	324/321
5258710	November 1993	Black et al.	324/309
5276398	January 1994	Withers et al.	324/318
5351007	September 1994	Withers et al.	324/322
5466480	November 1995	Zhou et al.	505/844

FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	US-CL
WO94/05022	March 1994	WO	H1/H1G

OTHER PUBLICATIONS

Banson, et al., "A probe for specimen magnetic resonance microscopy" (Feb. 1992) Investigative Radiology 27:157-164.
Black, et al., "A high-temperature superconducting receiver for nuclear magnetic resonance microscopy" (Feb. 5 1993) Science 259:793-795.

ART-UNIT: 225

PRIMARY-EXAMINER: Arana; Louis M.

ATTY-AGENT-FIRM: DeFranco; Judith A.

ABSTRACT:

A resonant coil for nuclear magnetic spectroscopy and microscopy is provided, in which the coil is in the form of nested, interrupted loops of a conductive material forming a distributed inductive element and having a plurality of capacitive elements with capacitance distributed over the periphery of the loops. The coil is preferably formed as a thin film of a superconductive material on an electrically nonconductive substrate.

7 Claims, 21 Drawing figures

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
Draw Desc | Image

☐ 9. Document ID: US 5619140 A Relevance Rank: 24

L3: Entry 7 of 9 File: USPT Apr 8, 1997

US-PAT-NO: 5619140
DOCUMENT-IDENTIFIER: US 5619140 A

TITLE: Method of making nuclear magnetic resonance probe coil

DATE-ISSUED: April 8, 1997

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Brey; William W.	Sunnyvale	CA		
Johansson; Marie E.	Palo Alto	CA		
Withers; Richard S.	Sunnyvale	CA		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Conductus, Inc.	Sunnyvale	CA			02

APPL-NO: 08/ 461558 [PALM]
DATE FILED: June 5, 1995

PARENT-CASE:
CROSS-REFERENCE TO RELATED APPLICATIONS This application is a continuation-in-part of U.S. patent application Ser. No. 08/409,506 by Richard S. Withers filed Mar. 23, 1995, now U.S. Pat. No. 5,585,723, and a continuation-in-part of U.S. patent application Ser. No. 08/313,624 by Richard S. Withers, Guo-Chun Liang and Marie Johansson filed Sep. 27, 1994, now abandoned, which is a continuation-in-part of 891,591, U.S. Pat. No. 5,351,007 by Richard S. Withers and Guo-Chun Liang filed Jun. 1, 1992, each of which is incorporated herein by reference.

INT-CL: [06] G01 V 3/00

US-CL-ISSUED: 324/318; 29/593
US-CL-CURRENT: 324/318; 29/593

FIELD-OF-SEARCH: 29/593, 29/599, 29/600, 29/601, 29/847, 324/318, 324/322, 324/300, 128/653.5

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
4346537	August 1982	Masujima et al.	29/593
4769883	September 1988	Nathanson et al.	29/847
4783641	November 1988	Hayes et al.	324/318
4894316	January 1990	Hjulstrom	29/847
5172461	December 1992	Pichl	29/847

FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	US-CL
WO94/05022	March 1994	WO	

ART-UNIT: 225

PRIMARY-EXAMINER: Arana; Louis M.

ATTY-AGENT-FIRM: DeFranco, Esq.; Judith A.

ABSTRACT:

A method of making a an NMR coil is provided. A coil is patterned of a film of a conductive material on a substrate. The coil mask is designed so that the resultant coil will have a lower resonant frequency than the desired frequency of the final coil.

The coil is placed in an apparatus where it is exposed to increasing current, preferably within a magnetic field such as will be used during operation. The current is gradually increased and the coil observed for changes in its resonant frequency. When the coil is exposed to its operating current without further change in its resonant frequency, it is trimmed by removal of part of the capacitive element of the coil to the desired frequency.

7 Claims, 21 Drawing figures

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
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Term	Documents
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L3: Entry 8 of 9 File: USPT Jan 14, 1997

DOCUMENT-IDENTIFIER: US 5594342 A
TITLE: Nuclear magnetic resonance probe coil with enhanced current-carrying capability

Abstract Text (1):
The conductive material in an RF coil disposed in the polarizing field of an NMR apparatus in miminized and the current density at each point in the coil kept constant by providing an inductive element and a set of tapered, interidigtated capacitors having a uniform gap therebetween. The invention maximizes the current-carrying capacity of the coil.

Brief Summary Text (3):
This invention relates to RF probes for Nuclear Magnetic Resonance spectroscopy and microscopy. More particularly, it relates to resonant coils for the transmission and reception of NMR signals. Even more particularly, it relates to superconductor coils on planar substrates.

Brief Summary Text (6):
The sensitivity of the spectrometer depends on a number of factors, including the strength of the static field, the closeness of the coupling between the RF coils and the sample, and the resistance of the RF coil. Currently, all commercial NMR spectrometers use RF coils made of a normal metal, such as copper, or a combination of normal metals. Much research has been coils have been made in the form of solenoids, saddle coils and birdcage coils, all of which have high filling factors. Similarly, researchers have suggested cooling of RF coils to reduce their resistance. However, the sensitivity of conventional normal-metal coils is limited by their resistance to a value less than that achievable with superconducting coils, even at low temperatures.

Brief Summary Text (9):
In addition to Marek, others have reported thin-film superconductor RF coils for magnetic resonance applications. For example, Withers, U.S. Pat. No. 5,276,398 describes a thin-film HTS probe for magnetic resonance imaging. It discloses a thin-film coil having inductors in a spiral of greater than one turn and capacitive elements extending from the inductors. Withers thus provides a thin film distributed capacitance probe coil. However, it does not address minimizing magnetic field disturbances by the coil, nor does it address maximizing the current carrying capacity of the coil.

Brief Summary Text (10):
Withers, et al., U.S. Ser. No. 08/313,624, which is incorporated herein by reference, presents one type coil design suitable for NMR spectroscopy. It consists of a single loop with a single interdigital capacitor along one edge. Although its RF performance is adequate, it has several deficiencies which the present invention corrects. Similarly, Black, U.S. Pat. No. 5,258,710, describes HTS thin-film receiver coils for NMR microscopy. Black discloses several embodiments, including split ring, solenoidal, saddle coils, birdcage coils and coils described as "Helmholtz pairs." Black's embodiments are essentially conventional NMR coil designs and do not address the unique characteristics of high-temperature superconductor materials.

Brief Summary Text (17):
In another embodiment of the invention, the fingers forming the capacitors are each divided into fingerlets to reduce magnetization. The fingerlets provide an advantage in any application in which an LC resonant structure is used and magnetization must be reduced. In yet another embodiment, the capacitors are tapered in the direction of the current to maintain a nearly constant current density throughout the coil.

Drawing Description Text (11):
FIGS. 6a, 6b and 6c depict an embodiment of the invention having tapered conductors;

Detailed Description Text (9):
FIG. 6a depicts a coil in which the interdigital conductors 50 are tapered along their length. The gap, or separation between conductors 52 is kept constant over its entire length. FIG. 6b shows an enlarged tip of a single conductor. The tapered conductor 50 is truncated at its tip. FIG. 6c shows an enlarged view of a pair of adjacent tapered conductors 50 with the uniform space 52 between conductors. Tapering the electrodes makes optimal use of the current-carrying ability of the superconducting film. Because the current carried by each finger decreases linearly toward its end as current is transferred to the fingers on the other (electrical) side of the capacitor, this approach maintains constant current per unit of film width. By placing the conductor where it is most needed, tapering also reduces the RF resistance of the coil. and hence its contribution to system noise. Similarly, as shown in FIG. 6d, the outermost 54 and innermost 56 lines of the capacitors carry only half of the current of the interior 58 capacitors, and need only be one-half the width of the other fingers. Similarly, because of their shorter length, the conductors nearer the center of the coil carry less current than the outer conductors.

Detailed Description Text (13):
Equation (1) requires that the voltage difference between the inner and outer lines be independent of angle, i.e., V.sub.o (.o slashed.)-V.sub.i (.o slashed.)=.DELTA.V, except at discontinuities. Equation (2) then requires that the inner and outer currents be simple linear functions of angle. With the boundary condition that the current be zero on the outer loop at .o slashed.=0 and zero on the inner loop at .o slashed.=.pi., we can derive the current and voltage distributions shown in FIG. 8. The linear variation in current along the length of each finger is the motivation for linearly tapering the finger width, as shown in FIG. 6. The constant voltage difference justifies a constant gap dimension (e.g., 50 .mu.m). The width of the gap is selected to withstand half of the peak transmit voltage.

Detailed Description Text (16):
Thus, the coil of FIG. 7 may be treated as a single-turn inductor with a tuning capacitor which is one-fourth of the total distributed capacitance. This coil design may be viewed as a planar, interdigital version of the coil design used for microscopy and described by Black, et al., "A probe for specimen magnetic resonance microscopy," Investigative Radiology 27, 157 (1992) and Black et al., "A high-temperature superconducting receiver for nuclear magnetic resonance microscopy," Science, vol. 259, p. 793, (1993). In fact, this analysis corroborates the design guideline to treat the two capacitors on the two sides of the structure as having simply their lumped value.

Detailed Description Text (37):
It will be appreciated by those skilled in the art that a number of variations are possible within the spirit and scope of the invention. For example, the invention is equally applicable to low temperature superconductors, and to normal metal conductors at room or low temperature. While low temperature superconductor coils do not offer the advantages of operating temperatures above 20 K, they are capable of achieving the extremely high Q. Normal metal coils do not achieve the high Qs of superconductor coils, but may benefit from application of certain aspects of the invention, and are at least minimally functional. It will also be appreciated that the coil design may be optimized for filling factor, depending upon the size and shape of the sample, and may be designed for any desired resonant frequency. Further, it will be appreciated that the invention is useful for NMR spectroscopy and microscopy and for magnetic resonance imaging.

Current US Cross Reference Classification (1):
324/318

Issued US Cross Reference Classification (1):
324/318

Field of Search Class/SubClass (1):
324/318

US Reference US Original Classification (5):
324/318

US Reference US Original Classification (19):

324/318

US Reference Group (5):
4636730 19870100 Bottomly 324/318

US Reference Group (19):
5276398 19940100 Withers et al. 324/318

Other Reference Publication (2):
Banson, et al., "A probe for specimen magnetic resonance microscopy" (Feb. 1992). Investigative Radiology27:157-164.

Other Reference Publication (3):
Black, et al., "A high-temperature superconducting receiver for nuclear magnetic resonance microscopy" (Feb. 5 1993) Science259:793-795.

CLAIMS:

1. An RF coil for magnetic resonance spectroscopy or microscopy comprising a conductive material comprising a capacitive element and an inductive element, wherein the inductive element comprises an interior loop comprising two interior fingers of width w and two exterior loops, each exterior loop comprising two exterior fingers of width about w/2 and the fingers are proximately disposed whereby a capacitive element is formed between adjacent pairs of fingers.

6. The coil of claim 1 wherein the interior fingers are tapered.

7. The coil of claim 2 wherein the interior fingers are tapered.

8. The coil of claim 3 wherein the interior fingers are tapered.

9. A capacitor for use with an inductor in an RF coil comprising a first elongate tapered finger, and a second elongate tapered finger, each finger having a wide end and a narrow end; the wide end of the first finger being proximately disposed to the narrow end of the second finger and the narrow the end of the first finger being proximately disposed to the wide end of the second finger, adjacent fingers forming a uniform gap therebetween, whereby a capacitive element is formed between the first and the second finger.

11. A capacitor for use with an inductive resonator of a magnetic resonance apparatus, comprising:

(a) a first set of elongate conducting fingers numbering at least one finger, each finger of the first set having a first terminal and a second terminal and each finger being essentially monotonically tapered from its first terminal to its second terminal;

(b) a second set of elongate conductive fingers numbering at least one finger, each finger having a first terminal and a second terminal, said second set disposed interdigitated with said first set whereby the first terminals of the first set lie proximal the second terminals of the second set and adjacent fingers define a gap of substantially uniform width therebetween.

16. A capacitive element for a magnetic resonance coil comprising:

(a) a first elongate finger of a conductive material, the first finger being slit over most, but less than all, of the length thereof into at least two fingerlets defining between the at least two fingerlets a first gap; and

(b) a second elongate finger of a conductive material, the first finger being proximately disposed to the second finger whereby a second gap is of essentially uniform width is defined between the first finger and the second finger, whereby a capacitive element is formed between the first finger and the second finger.

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L3: Entry 4 of 9 File: USPT Jun 11, 2002

DOCUMENT-IDENTIFIER: US 6404201 B1
TITLE: Magnetic resonance imaging RF coil

Brief Summary Text (2):
The present invention relates to the field of magnetic resonance imaging (MRI) systems and, more particularly, concerns radio frequency (RF) coils for use in such systems.

Brief Summary Text (3):
In MRI systems or nuclear magnetic resonance (NMR) systems, radio frequency signals are provided in the form of circularly polarized or rotating magnetic fields having an axis of rotation aligned with a main magnetic field. An RF field is then applied in the region being examined in a direction orthogonal to the static field direction, to excite magnetic resonance in the region, and resulting RF signals are detected and processed. Receiving coils intercept the radio frequency magnetic field generated by the subject under investigation in the presence of the main magnetic field in order to provide an image of the subject. Typically, such RF coils are either surface-type coils or volume-type coils, depending upon the particular application. Normally, separate RF coils are used for excitation and detection, but the same coil or array of coils may be used for both purposes.

Brief Summary Text (8):
In particular, the present invention provides a radio frequency (RF) coil system for magnetic resonance imaging/analysis comprising a primary coil element having a plurality of axial conductors spaced to form a generally tubular structure having two ends and defining a coil volume, and a first pair of spoiler coils. The spoiler coils each comprise a plurality of axial conductors spaced to form a generally tubular structure and define a coil volume. Each of the spoiler coils is positioned adjacent to and slightly overlapping an end of the primary coil. Each of the primary and spoiler coils is also adapted to carry an RF signal, wherein the signal in the rungs of the spoiler coils is 180 degrees out of phase with the signal in the rungs of the primary coil.

Brief Summary Text (10):
In a further aspect of the invention, a RF apparatus for use in a nuclear magnetic resonance (NMR) system is provided. The RF coil has a generally tubular structure defined by an inner wall and an outer wall, the inner wall defining an imaging volume. The RF coil also comprises a plurality of discrete electrically conductive members positioned between the inner wall and the outer wall which are equally circumferentially spaced around the tubular structure so as to form opposing pairs of conductive members. Each of the conductive members comprises a conductive loop having a primary coil section and a spoiler coil section at each end of the primary coil section configured such that a current flow of a signal on the loop in a cross-over region between each of the spoiler coils and the primary coil is in opposite directions.

Drawing Description Text (4):
FIG. 1 is a perspective view of a single quadrature birdcage coil according to the prior art.

Drawing Description Text (6):
FIG. 2A is a perspective view of the primary and spoiler birdcage coils of FIG. 2.

Detailed Description Text (2):
It is important in nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI) applications to maximize the signal-to-noise ratio of the system, and to irradiate all parts of the object under consideration with the same strength RF field.

In this regard, an important characteristic of an RF transmit coil is to provide a homogeneous magnetic field in the volume of the RF coil. Conversely, if a coil provides homogeneous excitation, it will also receive a NMR signals in a homogeneous fashion. Accordingly, in the discussion which follows, references to excitation distributions of the coils of the present invention apply with equal relevance to their use as a NMR receiver. In addition, although the present invention will be described with reference to a "birdcage" whole body transmit coil and an RF whole body transmit coil, the teachings herein are equally applicable to other types of volume coils used in a NMR imaging applications.

Detailed Description Text (3):
Referring now to FIG. 1, there is shown a perspective view of a single quadrature birdcage coil 10 according to the prior art. The birdcage coil 10 consists of two rings 12, 14 which form circular conductive loops which are connected to each other and spaced apart from each other by conductive connection members or rungs 16. Typically, there are eight, twelve or sixteen electrically conductive connecting members 16 joining the circular conductive rings 12, 14 and each rung is equally circumferentially spaced. Such quadrature transmit and receiving coils 10 are designed for receiving a variety of anatomical regions of the body such as the knee, leg, arm, or the entire body and are thus referred to as volume coils. The coils 10 are typically disposed around a hollow cylindrical drum (not shown) to provide structural support for the coil 10. The primary RF magnetic field of the coil 10 is perpendicular to the direction of the z-axis shown in FIG. 1.

Detailed Description Text (4):
For transmission, a waveform generator and power amplifier communicate RF waveforms to the conductive members to generate the RF magnetic field. For reception, electrical leads (not shown) are connected to the coil 10 to communicate the received signals to a data acquisition system as is known in the art. Such data processing systems typical comprise a data processing channel including an individual amplifier, filter, and A/D converter for processing the image signals received by a corresponding coaxial lead connected to the birdcage coil 10. The outputs of the data processing channels are then multiplexed and combined by a microprocessor according to a processing algorithm to produce and display an overall image signal.

Detailed Description Text (5):
An advantage of the birdcage coil design is that it creates a homogeneous RF field in the x-y plane and to a lesser extent, along the z-axis direction. A disadvantage of the coil, however, is that it has a significant amount of stray magnetic field beyond the endings of the coil. Preferably, the magnetic field should fall off rapidly outside of the imaging field of view to prevent the occurrence of image artifacts.

Detailed Description Text (6):
Referring now to FIG. 2 there is shown a schematic diagram of a transmitter/receiver system according to one embodiment of the present invention. The coil system of FIG. 2 comprises three birdcage coils, a primary birdcage coil 50 and two small birdcage coils referred to spoilers 52, 54 on either end of the primary birdcage 50. The birdcages are arranged such that the rung current in the spoilers 52, 54 is 180.degree. out of phase with the rung current flowing through the primary birdcage 50. This creates a counter field at each end 56, 58 of the primary birdcage coil 50 which drives the field amplitude down faster in those areas and, as a result, significantly reduces any stray magnetic field outside the field of view of the primary birdcage coil 50. An unequal power splitter 60 is used to shift the current phase of the signal received from amplifier 62 by 180.degree. before it is split by an equal power splitter 64 and transmitted to each of the spoilers 52, 54. Alternatively, the unequal power splitter 60 can comprise two amplifiers to accomplish the desired current phase shift. In such a case, unequal power splitter 60 comprises two amplifiers, one feeding the equal power splitter 64 and one feeding the primary birdcage 50 with a current 180.degree. out of phase with the signal transmitted to each of the spoiler birdcages 52, 54.

Detailed Description Text (10):
FIG. 2A is a perspective view of one embodiment of the primary birdcage oil 50 and .spoiler birdcage coils 52, 54 of FIG. 1. The rung and ladder configuration of the primary birdcage 50 and spoiler birdcages 52, 54 as well as the overlap of the end rings 70, 56 and 72, 58, respectively, can be clearly seen.

Detailed Description Text (14):
In a further preferred embodiment, the primary coil 84 is tapered from approximately a diameter of 55 cm at D2 to approximately 56.6 cm diameter at its center D1.

Issued US Original Classification (1):
324/318

Current US Original Classification (1):
324/318

Field of Search Class/SubClass (1):
324/318

US Reference US Original Classification (5):
324/318

US Reference Group (5):
6236206 20010600 Harthman et al. 324/318

CLAIMS:

16. A RF coil apparatus for use in an nuclear magnetic resonance (NMR) system having a generally tubular structure defined by an inner wall and an outer wall, said inner wall defining an imaging volume, the RF coil comprising a plurality of electrically conductive members positioned between said inner wall and said outer wall and equally circumferentially spaced around said tubular structure so as to form opposing pairs of conductive members, each of said conductive members comprising a conductive loop having a primary coil section and a spoiler coil section at each end of said primary coil section configured such that a current flow of a signal on said loop in a cross-over region between each of said spoiler coils and said primary coil is in opposite directions.

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Set	Items	Description
S1	1648966	MRI OR MAGNETIC(1W)(IMAG? OR IMAGING) OR MAGNETIC(W)RESONAN? OR NMR OR NUCLEAR()MAGNETIC()RESONANCE OR FTNMR OR FTMRI OR MAGNETORESONANCE OR PMR OR PROTON(W)MAGNETIC(W)RESONAN? OR MR()(IMAGE? OR IMAGING)
S2	5550	MC=(S01-E02A2 OR S03-E07A OR S01-E02A8A OR S01-E02A1 OR S03-E07C OR S05-D02B1 OR S03-C02F1)
S3	15862	IC=(G01R-003 OR G01N-024/08 OR G01V-003/A75)
S4	1660887	S1:S3
S5	71694	(COIL? ? OR SPIRAL???? OR CONCENTRIC????? OR WIRE????)(3N)(CONDUCT??????? OR ARRAY???)
S6	916382	(FIRST OR ONE OR TWO OR SECOND OR DIAMETER?????)(3N)(RING? ? OR END? ?)
S7	48031	(FIRST OR ONE OR TWO OR SECOND)(3N)DIAMETER?????
S8	956853	S6:S7
S9	5276	(ROD OR RODS)(3N)(LINEAR??? OR TAPER??????)
S10	263366	ELECTRIC???????(3N)(INTERCONNECT?????? OR INTER()CONNEC???????? OR CONNECT???????)
S11	182017	MAGNETIC??????(3N)(FLUX OR FLOW?????? OR DENSIT?????)
S12	4154	HOMOGENEOUS???????(3N)PATTERN??????
S13	14469	ORTHOGON???????(3N)(IMAG??????? OR PLANE? ?)
S14	3001	S4 AND S5
S15	87	S14 AND S8
S16	0	S15 AND S9
S17	13	S15 AND S10
S18	13	RD (unique items)
S19	74	S15 NOT S17
S20	2	S19 AND S11
S21	2	RD (unique items)
S22	72	S19 NOT S20
S23	0	S22 AND S12
S24	0	S22 AND S13
S25	57	S22 AND S1
S26	56	S25 AND S6
S27	1	S26 AND S7
S28	55	S26 NOT S27
S29	2	S28 AND (ROD OR RODS)
S30	53	S28 NOT S29
S31	46	RD (unique items)
S32	46	S31 AND (COIL? ? OR SPIRAL???? OR CONCENTRIC????? OR WIRE?????)
S33	39	S32 AND CONDUCT???????
S34	8	S33 AND DIAMETER?????
S35	8	RD (unique items)
S36	31	S33 NOT S34